Developing the Sterile Insect Technique for *Cryptophlebia leucotreta* (Lepidoptera: Tortricidae): Influence of Radiation Dose and Release Ratio on Fruit Damage and Population Growth in Field Cages

J. HENDRIK HOFMEYR,[1] JAMES E. CARPENTER,[2] AND STEPHANIE BLOEM[3]

J. Econ. Entomol. 98(6): 1924–1929 (2005)

ABSTRACT The effect of radiation dose and different release ratios of treated (T) to untreated (U) *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Tortricidae), on the incidence of fruit damage, the competitiveness of the treated males, and population growth was examined inside field cages. Navel orange trees were individually enclosed in large nylon mesh cages. Newly emerged adult moths treated with either 150 or 200 Gy of gamma radiation were released into the cages at ratios of 5T:1U or 10T:1U. The fruit was collected after 4 wk, and the number of damaged fruit and larval entries per cage were recorded for each treatment. Infested fruit was maintained in the laboratory until all emerging F_1 progeny were collected and outcrossed to untreated moths of the opposite sex. Treatment had a significant effect on the mean number of larval entries and on the number of undamaged fruit per cage. The number of larval entries as well as the number of F_1 progeny per cage decreased as the overflooding ratio increased. A significant reduction in egg hatch was observed in the progeny of crosses between F_1 females or F_1 males originating from the treatment cages compared with crosses of F_1 moths originating from the control cages. The lowest mean number of fertile F_1 adult females and males was obtained from the 150 Gy and 10T:1U ratio treatment. This treatment also showed the lowest per generation rate of increase (<1 from the parental [P_1] to the F_1 generation), suggesting that growth in the fertile population would have been prevented if releases of treated moths at this dose and ratio were maintained in the field.

KEY WORDS *Cryptophlebia leucotreta*, field cages, release ratios, insect competitiveness

Cryptophlebia leucotreta (Meyrick) (Lepidoptera: Tortricidae) is indigenous to large parts of Africa where it infests a variety of fruit and nuts from numerous wild and cultivated host plants (Hill 1983). Of the cultivated crops, it prefers citrus, but it also attacks many different deciduous, subtropical, and tropical plants (Economides 1979). *C. leucotreta* is the key pest of almost all varieties of citrus in South Africa (Stofberg 1954), and it is a serious pest of cotton and maize in tropical Africa (Angelini and Labonne 1970, Reed 1974). In South Africa, *C. leucotreta* has four to six nondiscrete generations per year (Stofberg 1954, Georgala 1969). Females lay between 100 and 250 individual eggs on fruit or foliage (Catling and Aschenborn 1974, Daiber 1978), and neonate larvae penetrate the fruit, where development is completed. Larvae leave the fruit and spin cocoons in the soil or in bark crevasses (Stofberg 1954, Georgala 1969).

Infestation by *C. leucotreta* generally causes the fruit to drop before harvest (Georgala 1969). Severe infestations can result in important crop losses and in losses at the packing house if newly infested fruit is not detected and removed. *C. leucotreta* is regarded as a major phytosanitary threat when it occurs in agricultural commodities exported to countries where it can possibly become established. Because of this concern, regulatory procedures are enforced by several countries, including the United States, when receiving citrus from South Africa. These regulatory procedures involve, inter alia, strict inspection of export produce at various times before and after harvest and the application of a stringent cold treatment designed to disinfest fruit during the export and shipping process.

Several control tactics are currently available to control *C. leucotreta* in South Africa. They include chemical control (Hofmeyr and Pringle 1998), behavioral interference such as mating disruption (Hofmeyr and Calitz 1991), attract and kill (J.H.H., personal communication), and augmentative biological control by using the egg parasitoid *Trichogrammatoidea cryptophlebiae* Nagaraja (Hymenoptera: Trichogrammatidae) (Newton and Odendaal 1990.). All of these tactics, however, have certain disadvantages that preclude their use as stand-alone tactics (Carpenter et al. 2004), and even in a multitactic approach often cannot produce the required degree of *C. leucotreta*

[1] Citrus Research International, P.O. Box 212, Citrusdal 7340, South Africa.
[2] USDA–ARS–Crop Protection and Management Research Unit, Tifton, GA 31793.
[3] International Atomic Energy Agency, 1804 Bowling Green Trail, Raleigh, NC 27613.

suppression. Our group is investigating the possible application of the sterile insect technique (SIT) to improve *C. leucotreta* control in South Africa and its use as an "action-ready" tool to eradicate an infestation of *C. leucotreta* should one occur in countries where the pest is not found.

Research on the radiation biology and documentation of inherited sterility in *C. leucotreta* was recently published by Bloem et al. (2003). They examined the effect of increasing doses of gamma irradiation on the fecundity and fertility of *C. leucotreta.* Newly emerged adults as well as mature pupae were treated with doses of radiation ranging between 0 and 350 Gy. They found that fecundity was not adversely affected by dose or radiation when untreated females were mated to treated males. However, the fecundity of treated females mated to either untreated or treated males declined precipitously as the dose of radiation increased. The dose at which 100% sterility was achieved in treated females was 200 Gy. Inherited effects resulting from treatment of parental (P_1) males with selected doses of radiation were recorded for the F_1 generation. Decreased F_1 fecundity and fertility, increased F_1 mortality during development, and a significant shift in the F_1 sex ratio in favor of males was observed.

Based on the results obtained by Bloem et al. (2003), we selected two doses of radiation, namely, 150 and 200 Gy for continued study. In this article, we report the results of field-cage experiments where we examined the effect of different release ratios of treated (T) to untreated (U) adult *C. leucotreta* on the incidence of fruit damage and on the competitiveness of the treated males. Two doses (150 and 200 Gy) and two release ratios (5T:1U and 10T:1U) were used in these experiments. The results presented here are discussed in the context of the implementation of a pilot project in South Africa to examine the suppressive capacity of irradiated *C. leucotreta* on a semicommercial scale.

Materials and Methods

Test Insects. *C. leucotreta* used in these experiments were provided by Ceder Biocontrol, Citrusdal, South Africa. The colony has been in continuous culture since 1978 (≈10 generations/yr). *C. leucotreta* were mass reared in glass jars (12 by 7 cm in diameter) on an autoclaved maize meal paste inoculated with *Rhizopus* sp. [as described by Ripley et al. 1939 and modified by Theron (1947) and Schwartz (1972)] as host material for the commercial production of the egg parasitoid *T. cryptophlebiae.*

For our experiments, normal cotton wool stoppers (used to seal the glass jars during larval development) were replaced with C-flute corrugated cardboard stoppers in 50 jars to aid in the collection of pupae. Pupae collected in the stoppers were removed from their cocoons, sorted by sex, placed individually in glass vials (5 by 1.5 cm in diameter) and allowed to emerge at 26 ± 1°C, 65–70% RH, and a photoperiod of 12:12 (L:D) h. Vials with newly emerged *C. leucotreta* males and females (24–48 h old) were transported in a small cooler to the INFRUITEC laboratory in Stellenbosch, South Africa, and exposed to gamma radiation. The irradiator is a panoramic Cobalt-60 point source that delivers a dose rate of 8.47–7.54 Gy/min (±5%, Fricke dosimetry), as described in Bloem et al. (2003). Adult moths were treated with doses of 0, 150, or 200 Gy.

Table 1. Treatments randomly assigned to 15 large field cages to examine the effect of different doses of radiation and release ratios of T to U *C. leucotreta* on the incidence of fruit damage and on the competitiveness of treated males

Dose (Gy)	Release ratio T:U	No. treated *C. leucotreta*		No. untreated *C. leucotreta*	
		T male	T female	U male	U female
0 (control)	0:1			10	10
150	5:1	50	50	10	10
150	10:1	100	100	10	10
200	5:1	50	50	10	10
200	10:1	100	100	10	10

Each cage enclosed an individual navel orange tree and each tree had 50 fruit (three cages per treatment = three replicates).

Release of Partially Sterile *C. leucotreta* into Field Cages. The experiment was conducted in a 10-ha conventionally managed7-yr-old Lina navel orange, *Citrus sinensis* (L.) Pers., orchard in Citrusdal, South Africa. Fifteen nylon-mesh field cages (2.60 by 2.60 by 2.60 m; mesh size 125 μm, Mesh-Tech Pty Ltd., Fourways, South Africa) with wooden and steel support frames were used to enclose individual trees (mean tree height 1.8 m). Trees were caged on 2 April 2003, ≈11 wk before fruit harvest. Naturally occurring fruit was thinned by hand and 50 fruit were left per tree. Male and female *C. leucotreta* were released (on opposite sides of each tree) according to treatment requirements (Table 1) on 2 May 2003. Treatments were randomly assigned to the field cages, and three replicates per treatment were initiated simultaneously. Insects were allowed to mate and lay eggs without disturbance for the duration of the trial. Cages were inspected daily, and fallen fruit were collected and taken to the laboratory. Fruit was inspected for damage, and the number of larval entries per fruit was recorded. The experiment was terminated on 24 June 2003 at which time all fruit remaining on the trees was removed and processed in the laboratory as described below. The total number of infested fruit per cage and the number of larval entries per 50 fruit were recorded per treatment replicate.

Field Cage F_1 Sterility Determination. In the laboratory, fruit were placed in individual 500-ml plastic containers with mesh lids and kept at 26 ± 1°C, 65–70% RH, and a photoperiod of 12:12 (L:D) h. Ten to 15 sections of plastic straw (2 cm in length) were placed inside each container to provide larvae with suitable cocooning sites. Fruit that were decaying too rapidly were cut open, and live larvae were carefully transplanted into jars with diet (one diet jar per infested fruit) to allow them to complete their development. Pupae collected from straws, and diet jars were transferred to individual 7-ml vials and allowed to emerge.

All emerged adults (F_1 generation) were sorted by sex and outcrossed to untreated *C. leucotreta* adults of the opposite sex. The pairs were kept at 26 ± 1°C, 65–70% RH, and a photoperiod of 12:12 (L:D) h in 90-ml clear plastic containers with snap-on lids, perforated to hold a moistened cotton dental wick. Moth pairs were allowed to mate and lay eggs until female death (≈14 d), and dead females were dissected to confirm their mating status (spermatophore in the bursa copulatrix; Ferro and Akre 1975). The containers were cut in half vertically, and the total number of eggs as well as the number of eggs that hatched was counted in each container. Percentage of egg hatch was used to categorize the parentage of the F_1 male or female reared from the infested fruit. When percentage of egg hatch was <5% the F_1 adult was designated as the progeny of a T male (150 or 200 Gy) and a U female (fertile) female, and when egg hatch was ≥5% the F_1 was designated as progeny of a U male and a U female. It was assumed that T females were completely sterile, and as such, produced no F_1 progeny (Bloem et al. 2003). The per generation rate of increase occurring from the P_1 to the F_1 generation in each cage was calculated by dividing the number of F_1 male and female progeny produced by a fertile (U male by U female) mating by the number of P_1 U male (10) and U female (10) released into each cage (Table 1).

Statistical Analysis. The number of larval entries, the number of undamaged fruit, and the number of F_1 adult *C. leucotreta* emerging from the fruit collected from the different treatments were subjected to analysis of variance (ANOVA), and the residual deviations were tested for non-normality (Shapiro and Wilk 1965). There was not enough evidence ($P < 0.05$) against normality, thus data transformation was unnecessary. When the statistical model indicated significant treatment effects, differences among treatment means were separated by the Tukey–Kramer statistic ($P \leq 0.05$) for multiple comparisons. The data also were sorted by dose of radiation (150 or 200 Gy) and regression analysis (PROC GLM) (SAS Institute 1989) was used to examine the relationship between the number of treated *C. leucotreta* released into each cage and the number of larval entries, the number of undamaged fruit, and the number of F_1 adult *C. leucotreta* emerging in each treatment.

The number and percentage of hatched eggs laid by the F_1 moths (that emerged from infested fruit and were crossed with untreated adults of the opposite sex) were analyzed using a two-factor ANOVA, with F_1 adult sex and cage treatment as sources of variation (PROC ANOVA) (SAS Institute 1989). The percentage of F_1 males and females that were fathered by an untreated (fertile) male was analyzed using ANOVA, with cage treatment as the source of variation (PROC ANOVA) (SAS Institute 1989). Residual deviations were tested for non-normality (Shapiro and Wilk 1965). Because there was not enough evidence ($P < 0.05$) against normality, transformation of the data was unnecessary. When the statistical model indicated significant treatment effects, differences among treatment means were separated by the Tukey–Kramer statistic ($P \leq 0.05$) for multiple comparisons.

Table 2. Effect of dose of radiation (150 or 200 Gy) and release ratio (5T:1U or 10T:1U) on the degree of larval damage to fruit and on the number of F_1 *C. leucotreta* emerging from the damaged fruit per treatment

Treatment		Mean ± SD no./cage		
Radiation dose (Gy)	Release ratio (T:U)	Larval entries/ 50 fruit	Undamaged fruit	F_1 moths emerged
0 (control)	0	234.7 ± 9.1a	1.7 ± 1.2a	92.0 ± 13.0a
150	5:1	171.0 ± 37.3ab	6.3 ± 3.1ab	80.3 ± 27.3ab
150	10:1	113.0 ± 72.3b	14.3 ± 14.4b	37.7 ± 26.5b
200	5:1	91.3 ± 42.8b	14.0 ± 4.6b	38.3 ± 16.7b
200	10:1	104.7 ± 81.3b	19.3 ± 19.3b	44.0 ± 33.6ab

Means within each column followed by the same letter are not significantly different ($P > 0.05$).

Results

The treatments assigned to the field cages had a significant effect on the mean number of larval entries ($F = 3.52$; df = 4, 14; $P = 0.048$), the mean number of undamaged fruit ($F = 3.40$; df = 4, 14; $P = 0.05$), and the mean number F_1 adults emerging from the fruit collected in each cage ($F = 3.40$; df = 4, 14; $P = 0.05$) (Table 2). Significantly more larval entries were recorded and significantly more F_1 adults were obtained from the fruit collected from the control cages than from fruit originating from any of the cages receiving treated insects. In addition, significantly more undamaged fruit was collected from field cages receiving one of the four treatments than from cages serving as a control.

At the 150-Gy treatment dose, regression analysis revealed a significant linear relationship between the number of treated *C. leucotreta* adults released into each cage (5T:1U or 10T:1U release ratio) and the number of larval entries, the number of undamaged fruit, and the number of F_1 adults emerging from collected fruit. The mean number of larval entries decreased as the number of treated *C. leucotreta* released into the cages increased ($y = 223.7 - 12.2x$; $F = 11.6$; df = 1, 8; $P < 0.0114$). Similarly, the mean number of F_1 adults that emerged from the fruit collected from each cage decreased as the number of treated *C. leucotreta* released into the cages increased ($y = 97.2 - 5.4x$; $F = 8.35$; df = 1, 8; $P < 0.0233$). Furthermore, as the number of treated *C. leucotreta* increased, there was an increase in the mean number of undamaged fruit per cage ($y = 1.11 + 1.3x$; $F = 10.11$; df = 1, 8; $P < 0.0155$). Regression analysis also revealed significant linear relationships between the number of treated *C. leucotreta* released into each cage and the number of larval entries as well as the number of undamaged fruit when the dose used to treat the *C. leucotreta* was 200 Gy. The mean number of larval entries detected per cage decreased as the number of 200 Gy-treated *C. leucotreta* released in the cages increased ($y = 208.6 - 13.0x$; $F = 6.05$; df = 1, 8; $P < 0.0434$). As the number

Table 3. Effect of dose of radiation (150 or 200 Gy) and release ratio (5T:1U or 10T:1U) of treated *C. leucotreta* released per cage on the number and percentage of eggs that hatched from eggs laid by F_1 moths emerging from fruit collected from the field cages

Cage treatment (dose of radiation and release ratio)	Mean ± SD eggs hatched		Mean ± SD % eggs hatched	
	F_1 female	F_1 male	F_1 female	F_1 male
Control (0 Gy, 0:1)	564.4 ± 179Aa	424.5 ± 167Aa	93.6 ± 14Aa	88.1 ± 18Aa
150 Gy, 5:1	449.0 ± 246Aab	232.3 ± 229Bb	73.1 ± 33Ab	48.2 ± 43Bb
150 Gy, 10:1	284.3 ± 289Ab	107.7 ± 175Bc	43.5 ± 37Ac	27.4 ± 41Ac
200 Gy, 5:1	509.1 ± 257Ab	248.5 ± 213Bb	72.6 ± 32Ab	57.3 ± 42Ab
200 Gy, 10:1	426.8 ± 248Ab	210.4 ± 214Bb	69.4 ± 39Ab	47.9 ± 45Bb

Means within each row for each variable followed by the same uppercase letter are not significantly different ($P > 0.05$); means within each column followed by the same lowercase letter are not significantly different ($P > 0.05$).

of treated *C. leucotreta* in the cages increased, there was a corresponding increase in the mean number of undamaged fruit per cage ($y = 2.83 + 1.8x$; $F = 7.28$; df = 1, 8; $P < 0.0307$).

Statistical analysis of the egg data collected from F_1 moths that emerged from infested fruit and were crossed with untreated adults of the opposite sex revealed that the mean number of eggs that hatched was significantly affected by the cage treatment ($F = 57.91$; df = 4, 876; $P < 0.0001$), sex of the F_1 moth ($F = 94.34$; df = 1, 876; $P < 0.0001$), and an interaction between cage treatment and insect sex ($F = 7.71$; df = 4, 876; $P < 0.0001$) (Table 3). There was no significant difference in the mean number of eggs that hatched from crosses involving F_1 males and F_1 females in the cages that served as controls; however, in cages receiving treated *C. leucotreta*, significantly fewer eggs hatched when crosses involved F_1 males (than when crosses involved F_1 females). Significantly fewer eggs hatched from crosses involving F_1 males in cages where treated *C. leucotreta* were released than from crosses of F_1 males in the control cages. Similarly, fewer eggs hatched from crosses involving F_1 females in cages where treated *C. leucotreta* were released than from crosses of F_1 females in the control cages. The lowest mean number of eggs that hatched for both F_1 males and F_1 females was obtained in cages receiving *C. leucotreta* treated at 150 Gy and released at a ratio of 10T:1U. Statistical analysis of the egg data collected from F_1 moths also showed that the mean percentage of eggs that hatched was significantly affected by the cage treatment ($F = 70.92$; df = 4, 876; $P < 0.0001$), sex of the F_1 moths ($F = 45.56$; df = 1, 876; $P < 0.0001$), and an interaction between cage treatment and sex ($F = 2.89$; df = 4, 876; $P < 0.0216$) (Table 3). Similarly, the mean percentage of eggs that hatched was lower for F_1 males than F_1 females, and lower for *C. leucotreta* emerging from treatment cages than from control cages. The lowest mean percentage of eggs that hatched for both F_1 males and F_1 females was obtained in cages receiving *C. leucotreta* treated at 150 Gy and released at a ratio of 10T:1U.

The type of cage treatment significantly affected the mean number of fertile (=progeny of an untreated male) F_1 male moths ($F = 3.67$; df = 4, 14; $P = 0.0432$) and the mean number of fertile F_1 female moths ($F = 8.36$; df = 4, 14; $P = 0.0031$) emerging from fruit removed from the cages (Table 4). Significantly fewer fertile F_1 males and females were produced in cages receiving treated *C. leucotreta* at a release ratio of 10T:1U and in cages receiving 200-Gy treated *C. leucotreta* at a release ratio of 5T:1U. The cage treatment that produced the lowest mean number of fertile F_1 males and females (150-Gy-treated *C. leucotreta* at a release ratio of 10T:1U) also had the lowest per generation rate of (reproductive) increase from the P_1 to the F_1 generation. All treatments had a lower rate of increase than the control, suggesting that all treatments would suppress the population growth of fertile *C. leucotreta* (Table 4). However, cages receiving 150-Gy-treated *C. leucotreta* at a release ratio of 10T:1U resulted in a rate of increase that was <1 for both males (0.97) and females (0.9), indicating that the fertile population would be in a slight decline from the P_1 to the F_1 generation (Fig. 1). Because the mean per generation rate of increase for fertile males and females (0.935) from this treatment is ≈1, additional releases of 100 pairs of 150-Gy-treated *C. leucotreta* in each generation would be sufficient to maintain at least a ratio of 10T:1U (and F_1 sterile):untreated [fertile] *C. leucotreta*, thereby preventing growth in the fertile population.

Discussion

In this article, we report the results of field cage experiments in which we examined the effect of different release ratios of T to U adult *C. leucotreta* on the incidence of fruit damage and on the competitiveness

Table 4. Effect of dose of radiation (150 or 200 Gy) and release ratio (5T:1U or 10T:1U) of treated *C. leucotreta* on the mean number of fertile F_1 female moths emerging from fruit removed from the cages, and the rate of increase for the P_1-F_1 generation

Cage treatment (dose of radiation and release ratio)	Mean ± SD fertile moths (progeny of nonirradiated males)		P_1-F_1 reproductive rate of increase	
	F_1 female	F_1 male	Female	Male
Control (0 Gy, 0:1)	48.0 ± 6.1a	42.3 ± 10.5a	4.8×	4.23×
150 Gy, 5:1	34.3 ± 16.8ab	25.0 ± 14.4ab	3.43×	2.50×
150 Gy, 10:1	9.0 ± 5.6b	9.7 ± 7.0b	0.90×	0.97×
200 Gy, 5:1	12.3 ± 5.8b	16.0 ± 12.8b	1.23×	1.60×
200 Gy, 10:1	14.3 ± 11.2b	14.0 ± 12.5b	1.43×	1.40×

Means within each column followed by the same letter are not significantly different ($P > 0.05$).

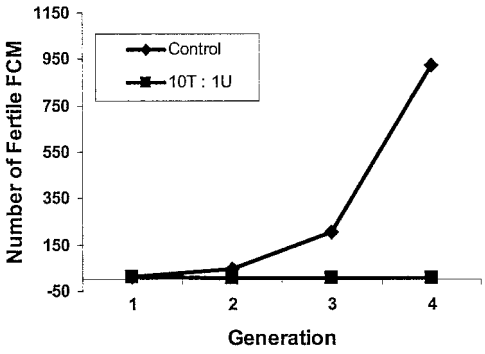

Fig. 1. Comparison of the estimated increase in the number of fertile *C. leucotreta* in a control population and a population subjected to releases of 150-Gy-treated *C. leucotreta*. The control population began generation 1 with 10 pairs of fertile (U) *C. leucotreta* with a reproductive rate of 4.52× per generation. The treatment population also began generation 1 with 10 pairs of fertile *C. leucotreta*, with a release of 100 pairs of 150-Gy-T *C. leucotreta* at the beginning of each of the first three generations (=to a release ratio of 10T:1U in generation 1), which reduced the reproductive rate to <1× per generation.

of the treated males. Compared with the control cages, all treatments involving the release of treated *C. leucotreta* adults, irrespective of dose used (150 or 200 Gy), reduced the number of larval entries to the fruit (Table 2) and the number of damaged fruit per treatment. In cages receiving treated *C. leucotreta* at a 10T:1U release ratio, the mean number of undamaged fruit collected was 8–10 times greater than the mean number of undamaged fruit collected from the control cages (Table 2). The mean number of F_1 adult progeny produced from the *C. leucotreta* released in the cages was also significantly reduced when the cage treatment included the release of treated *C. leucotreta* (Table 2).

Our results showed that the fertility of the F_1 adults produced from cages receiving treated *C. leucotreta* was significantly reduced compared with the fertility of F_1 adults produced from the control cages (Table 3), indicating that the treated *C. leucotreta* males released into the field cages had competed successfully with untreated *C. leucotreta* males for untreated females. Depending on the dose of radiation and the release ratio, ≈30–40% of the F_1 adult *C. leucotreta* produced were sterile progeny of an irradiated P_1 father. The mean number of fertile *C. leucotreta* males and fertile females produced in the F_1 generation was significantly greater in the control cages than in cages receiving treated *C. leucotreta* (Table 4), which resulted in a higher per generation rate of increase (from the P_1 to the F_1 generation) in the control cages. Our results are similar to those reported in other field cage studies by Bloem et al. (1999) on codling moth, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae) and by Hight et al. (2005) on cactus moth, *Cactoblastis cactorum* (Berg) (Lepidoptera: Pyralidae). However, Bloem et al. (1999) examined the effect of different doses of radiation (100 and 250 Gy), but they did not change the release ratio, whereas Hight et al. (2005) assessed the effect of different release ratios of male only versus male and female releases by using moths treated with only one dose of radiation (200 Gy). Nevertheless, both studies conclude that the population growth in their respective pests could be significantly impacted by the release of irradiated conspecifics even when the release ratio was relatively low.

Our results demonstrated the efficacy of irradiated and released *C. leucotreta* in reducing fruit damage and in lowering the number of fertile F_1 adults produced under the controlled environment of a field cage. However, it is difficult to envision the potential impact of releasing irradiated *C. leucotreta* against a fertile population unless the efficacy obtained in the field cage experiments is projected for several generations. In this projection, we simulate the typical scenario of a sterile insect release program in which irradiated *C. leucotreta* would be released continuously from the beginning of the growing season when *C. leucotreta* populations would be at a low level. In Fig. 1, we compare the estimated rate of increase in the number of fertile *C. leucotreta* in a "control" population with the number of fertile *C. leucotreta* in a population subjected to releases of *C. leucotreta* treated with 150 Gy. The control population in generation 1 begins with 10 pairs of fertile (untreated) *C. leucotreta* with a mean reproductive rate for males and females of 4.52× per generation (Table 4). The "treatment" population also begins generation one with 10 pairs of fertile *C. leucotreta* and is subjected to a release of 100 pairs of *C. leucotreta* treated with 150 Gy at the beginning of each of the first three generations (=to a 10T:1U release ratio each generation), which reduces the mean reproductive rate for males and females to <1× per generation (0.935×). In this model, based upon the data collected in our field cage study, the fertile population receiving irradiated *C. leucotreta* (treatment population) declines slightly, whereas the number of fertile *C. leucotreta* in the control population increases by >9,000%. Our results strongly support the continued development and assessment of the sterile insect technique as a control tactic for *C. leucotreta*. Season-long releases of *C. leucotreta* treated with 150 Gy into a relatively isolated citrus-growing area would be useful to evaluate their performance and the efficacy of achieved release ratios under field conditions.

The SIT has been very successful when applied against a number of pest Diptera [including the screwworm, *Cochliomyia hominivorax* (Coquerel) (Diptera: Calliphoridae) and the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae)] and Lepidoptera, namely, in the pink bollworm program in the United States, and the codling moth program in Canada (Bloem and Carpenter 2001). More recently, the development of the SIT is being pursued to stop the spread of the cactus moth in the United States (Carpenter et al. 2001, Hight et al. 2005). We can now add *C. leucotreta* to the list of pestiferous Lepidoptera where SIT will be evaluated as an environmentally friendly pest control tactic.

Acknowledgments

We thank M. Hofmeyr for technical assistance; K. Slabbert (Radiation Biophysics, iThemba LABS, Somerset West, South Africa) for assistance with the dosimetry of the Co^{60} irradiator; R. Layton for assistance with statistical analysis; and O. G. Marti for comments on earlier drafts of the manuscript. We thank B. Barnes (INFRUITEC Nietvoorbij Fruit, Vine and Wine Research Institute, Stellenbosch, South Africa) for providing laboratory space and the use of the Co^{60} irradiator, and Ceder Biocontrol (Citrusdal, South Africa) for providing insects and diet. Funding for this project was provided by a grant from the USDA–FAS, from project SAF 5-002 from the Department of Technical Cooperation of the International Atomic Energy Agency in Vienna, Austria, and from Citrus Research International Pty Ltd.

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Received 21 June 2005; accepted 17 August 2005.